

**Preliminary Commissioning Plan  
Cooling Tower Replacement Project  
Andrew W. Briedenback Research Center  
Environmental Protection Agency  
Cincinnati, Ohio**

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## **1.0 COMMISSIONING PROCESS DESCRIPTION**

System Commissioning is a process of review, evaluation, testing and documentation of building systems in cooperation with the Building Owner, the Design Team and System Installers, to demonstrate that the constructed facility:

1. Is installed and adjusted in accordance with the design requirements and the manufacturer's recommendations; and,
2. Will operate in accordance with the designer's specifications and meet the building Owner's Performance Criteria under all normal and upset operating conditions.

The System Commissioning Process begins in the Design Phase with the preparation of records of design intent, basis of design and system performance acceptance criteria. Design Phase Commissioning includes submittals reviews for Commissionability, Maintainability and Best Application.

The Construction Phase Commissioning Process includes sufficient testing, documentation, and Owner training to ensure that the level of system performance demonstrated at the completion of the system installation can be maintained throughout the life of the system.

Finally, the commissioning process focuses the contractor training efforts to provide an effective transfer of knowledge and experience to the building operations team.

## **2.0 PROJECT DESCRIPTION**

The Cooling Tower Replacement project at the AWBERC facility is intended to replace the existing cooling towers at this facility and to modify the condenser and chilled water pumping systems. The condenser water pumps are being replaced and tied to the three existing centrifugal chillers. The chilled water pumping system is being converted to a primary secondary system and tied into the existing building distribution system. This project is the first phase of a larger building HVAC system upgrade to be completed over several subsequent phases.

### *Design Guidelines*

The design guidelines have been developed as part of the overall master planning of the facility HVAC upgrade. Generally, the Cooling Tower Replacement project is intended to upgrade the condenser water system supporting this facility to accomplish the following goals:

1. Provide adequate cooling tower capacity for the existing chillers;
2. Upgrade condenser water pumps to support the chiller and provide redundancy to maintain continuous facility operational availability;
3. Upgrade the chilled water distribution system to a primary secondary system integrated with the existing chilled water distribution system.

### **3.0 COMMISSIONING TEAM RESPONSIBILITIES**

#### **3.1 Commissioning Team**

The following parties, included as members of the Commissioning Team, will have the general responsibilities outlined below. Team member responsibilities specific to each system are outlined in the Functional Performance section of this Commissioning Plan.

##### **Commissioning Authority (CxA): Olsson Associates**

Provide engineering and technical labor necessary to coordinate and execute the commissioning plan. Coordinate and execute Design and Construction Phase Commissioning activities, including design phase submittal reviews, development of commissioning specification language for bid specifications, assistance during bidding and construction commissioning. Coordinate documentation of all commissioning and training procedures performed by the Commissioning Agent, the Contractor, Subcontractors and others. Plan and conduct the commissioning team meetings to plan, scope, coordinate, schedule activities and assist with problem resolution. Provide final commissioning results in report form and advise EPA-HQ and EPA-AWBERC with respect to final approval of commissioning results.

##### **Environmental Protection Agency AWBERC (EPA- AWBERC)**

Provide personnel to observe specific commissioning procedures as deemed necessary by EPA. Witness specific commissioning procedures as outlined, and provide documentation or approval of procedures as required to the Commissioning Agent (CA). Provide information required by the commissioning agent to include in the commissioning report. Participate in the commissioning team meetings to plan, scope, coordinate, schedule activities and resolve problems. Sign-off (final approval) on individual commissioning tests as completed. Provide final approval of commissioning results.

##### **Environmental Protection Agency Headquarters (EPA-HQ)**

Provide contracting authority, review and final approval of commissioning results.

##### **Design Team: Cannon Design**

Cooperate in design phase submittal reviews. Provide Design Intent and Basis of Design Documentation to the CxA for review and assistance in preparation of commissioning testing protocols and acceptance criteria. Provide specific design comment responses for inclusion in commissioning documentation. Assist CxA in incorporating commissioning specification language in contract documents. Witness specific commissioning procedures as outlined, and provide documentation or approval of procedures as required to the Commissioning Agent. Provide System Descriptions and approval of all Acceptance Criteria. Provide any documentation of design or design related construction activities as appropriate to include in Commissioning Report. Participate in the commissioning team meetings to plan, scope, coordinate, schedule activities and resolve problems.

**Test and Balance Subcontractor:**

Submit for approval to the Commissioning Agent a TAB Plan to meet all project performance requirements prior to commencement of work. Complete testing, adjusting and balancing in accordance with the approved TAB plan. Provide all documentation required by the TAB specification to include in Commissioning Report. Participate in the commissioning team meetings to plan, scope, coordinate, schedule activities and resolve problems.

**General Contractor:**

Facilitate the coordination of the commissioning work by the Commissioning Agent, and ensure that commissioning activities are being scheduled into the master schedule. Ensure that all Subcontractors and Vendors execute their commissioning responsibilities according to the Contract Documents and schedule. Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the Commissioning Agent. Participate in the commissioning team meetings to plan, scope, coordinate, schedule activities and resolve problems. General Contractor shall include no less than one Commissioning Scoping Meeting and 4 Commissioning Team meetings in his work.

**Installing Contractors (Sub):**

Adequately inform all vendors of their responsibilities with regard to the commissioning process (as outlined herein). Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force

Provide normal start up of all installed systems and equipment to ensure systems are started and fully operational prior to commencement of commissioning. Provide *signed reports and documentation* to confirm completion of start up and testing requirements outlined in the project specification. Documentation should include the following:

1. Outline of start up and testing procedures and requirements,
2. Actual field data (pressures, temperatures, flows, electrical readings, etc.) taken during the testing to support its successful completion,
3. Signature of individual responsible for task completion,
4. Date of completion, and
5. A record of any deviations from established start up acceptance criteria with an explanation of the deviation.

Provide sufficient labor and qualified technical support to the commissioning agent to operate equipment during the acceptance phase commissioning process. Provide labor, materials and technical support to correct any deficiencies found during commissioning immediately so as not to impede the completion of commissioning. Participate in the commissioning team meetings to plan, scope, coordinate, schedule activities and resolve problems. Installing Contractors (Sub) shall include no less than one Commissioning Scoping Meeting and 4 Commissioning Team meetings in his work.

Provide necessary personnel for training sessions, as outlined in the project specification, to be coordinated by the Commissioning Agent. Cooperate with the Commissioning Agent to schedule training in accordance with the training agenda provided by the Commissioning Agent during the construction phase of the project.

### **Vendors**

Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force. Assist in equipment testing per agreements with Subs. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor. Provide information requested by Commissioning agent regarding equipment, equipment sequence of operation and testing procedures. Review test procedures for equipment installed by factory representatives.

Provide labor, materials and qualified technical support to correct any deficiencies found during commissioning immediately so as not to impede the completion of commissioning. Participate in the commissioning team meetings as needed to plan, scope, coordinate, schedule activities and resolve problems.

Provide necessary personnel for training sessions, as outlined in the job specification, to be coordinated by the Commissioning Agent. Cooperate with the Commissioning Agent to schedule training in accordance with the training agenda provided by the Commissioning Agent. See Commissioning Specification section 01810, 1.5, F, for a complete description of responsibilities.

### **System To Be Commissioned**

The following systems will be included in the commissioning process. Additional systems may be added to the process as the design progresses:

<b>Systems</b>
Central Cooling Plant Primary/Secondary Pumping Systems
Condenser Water Pumping System
Cooling Towers
Temperature/Pressure Control Systems (Building Management System Modifications associated with the work of this project)
Electrical Systems Supporting Project Installed Systems & Components
Training/ O & M Manual

## **4.0 COMMISSIONING RESPONSIBILITY MATRIX**

Table 1 below contains a Responsibility Matrix. This table, in conjunction with the Section 5.0 Commissioning Duration Schedule, is intended to aid the Commissioning team members in identifying areas where they have responsibilities to perform certain tasks or to provide documentation for the commissioning process. Note that the matrix

will be updated upon contract award to reflect specific responsibilities of all successful contractors and sub-contractors.

## **5.0 COMMISSIONING DURATION SCHEDULE**

A Coordination Schedule will be prepared during the early construction phase of the project to provide guidance to the successful contractors as to the level of involvement and the approximate durations of commissioning activities. This schedule forms the basis for incorporating commissioning into the overall construction schedule. Further, the schedule will provide guidance as to the activities that must be complete prior to commissioning activities commencing.

Commissioning durations will be provided for use in coordination only and may change as a result of changes in the construction and/or commissioning schedules. This duration schedule is provided as a guide to specific commissioning activities that will occur over the course of this project and not as an obligation of the Commissioning Agent. The Commissioning Agent may issue revisions to this duration schedule as the project progresses.

*See Appendix A – Sample Commissioning Duration Schedule*

**Table 1: Commissioning Responsibility Matrix**

Systems	Team Members									
	CxA	EPA-HQ	EPA-AWBERC	Cannon Design	TAB	General Contractor	Mech. Sub	Elec. Sub	Temp. Control Sub	Equip. Vendor
Central Cooling Plant Primary/Secondary Pumping Systems	P/C/V/S	W/A	W/A	A	P/C/S	C/S/W	P/C/S	P/C/S	P/C/S	P/C/S
Condenser Water Pumping System	P/C/V/S	W/A	W/A	A	P/C/S	C/S/W	P/C/S		P/C/S	P/C/S
Cooling Towers	P/C/V/S	W/A	W/A	A	P/C/S	C/S/W	P/C/S	P/C/S	P/C/S	P/C/S
Temperature/Pressure Control Systems (Building Management System Modifications associated with the work of this project)	P/C/V/S	W/A	W/A	A	P/C/S	C/S/W	P/C/S		P/C/S	P/C/S
Electrical Systems Supporting Project Installed Systems & Components	P/C/V/S	W/A	W/A	A		C/S/W	P/C/S	P/C/S	P/C/S	P/C/S
Training/ O & M Manual	P/C/V/S	A	A	P/A	P/C/S	C/S	P/C/S	P/C/S	P/C/S	P/C/S

Note 1: Wastewater Treatment Contractor and Equipment Supplier will have P/C/S responsibilities.

Note 2: Automation Contractor/Supplier will have P/C/S responsibilities

**Matrix Key**

**P – Performance:** Requirement for participation and or performance of specific commissioning tasks and documentation.

**C – Coordination:** Indicates requirement for coordination of commissioning tasks.

**V – Verification:** Indicates requirement for task and documentation verification of work performed by others.

**S – Schedule:** Identify duration and sequence activities relative to system start-up and commissioning tasks.

**W – Witness:** Witness commissioning tasks. (optional)

**A - Approved:** Provide, review, and approval on the advice of the Commissioning Agent.

## **6.0 CONSTRUCTION PHASE COMMISSIONING**

### **6.1. COMMISSIONING INSPECTION/TESTING REQUIREMENTS**

This section of the commissioning plan provides the Commissioning Team with a general outline of the inspections and testing that will be required to complete the commissioning process. Each successive commissioning protocol (FIV, OPT, FPT) is an integral part of the commissioning process. Each successive step must be successfully completed on a system and its components prior to proceeding to the next step in the process.

As an attachment to this Commissioning Plan, a Commissioning Document List will be developed and maintained during the construction phase of the project. This list will provide a target for commissioning completion and a mechanism for evaluating the progress of the commissioning process.

### **6.2. FIELD INSTALLATION VERIFICATION (FIV)**

Field Installation Verification (FIV) involves the inspection of all systems and system components to verify proper installation and compliance to plans and specifications. This step must be performed and completed prior to beginning the Operational Performance Testing for any given system.

The installation verification will help insure that the system may be operationally checked out without any delays (see OPT below). The process will make sure that all equipment and devices involved in a system are completed before the system is operated.

Field Installation Verification is the responsibility of the Commissioning Agent, the General Contractor and the Installing Contractors (Sub). *The Installing Contractor and Vendor are responsible for reviewing the FIV forms provided during the construction phase by the CxA and informing the CxA when the equipment is completed and ready for FIV inspections.* The CxA will inspect and document that the components are completed and installed correctly.

The FIV will be an ongoing process during the construction installation phase. Systems will be broken into several sub-systems during this phase and can be checked off without the completion of the entire system.

### **6.3. OPERATIONAL PERFORMANCE TESTING (OPT)**

The purpose of Operational Performance Testing (OPT) is to verify that all commissioned systems and sub-systems have been started-up and operated in accordance with the Contract Documents. The OPT will proceed only after every Field Installation Verification (FIV) procedure applicable to a given system is complete.

The OPT will demonstrate that each component of the commissioned system operates as intended by the Contract Documents. Each system element, each element of the operational sequence, and every alarm must operate properly. All mechanical equipment must be started and operated to verify correct performance.

*Completion of the OPT for each system and its component parts is the responsibility of the Installing Contractor and Vendors.* The Installing Contractor and Vendors shall give a minimum of two weeks notice to the GC, EPA-AWBERC and CxA prior to execution of OPT's. *All* OPT's shall be witnessed by the CxA unless, in the sole judgment of the CxA, a random sample of the component OPT's may be witnessed and documented to accomplish the goals of the Commissioning process.

OPT's shall be performed on 100% of the installed equipment, components and systems as defined in the Commissioning Plan. No sampling strategies may be used for Operational Performance inspections and procedures. The installing contractor's site technician or vendor performing the line item task shall initial and date each procedure in the OPT and/or manufacturer's field checkout sheets. Only individuals having direct knowledge of a line item being completed shall check and initial the forms.

The CxA will provide OPT check sheets to the General Contractor and Installing Contractors for execution of this work. If a complex piece of equipment is provided with a manufacturer's start up report form, this form may be used as an attachment to the OPT. Reference shall be made on the OPT to this manufacturer's report on appropriate line items. To the extent that additional tasks are required by the OPT, these shall be performed in addition to the manufacturer's start up requirements. These completed original forms will be delivered to the Commissioning Agent and become part of the Commissioning Record.

#### **6.4. FUNCTIONAL PERFORMANCE TESTING**

All of the equipment, systems, sub-systems, and components shall be tested and evaluated for conformance with the performance requirements outlined in the Basis of Design Document, the Functional Performance Test (FPT) protocols, and the Contract Documents. All Operational Performance Tests must be complete for all systems before the FPT can begin unless directed otherwise by the CA.

The purpose of Functional Performance Testing is to demonstrate that each system and all systems working together operate in a responsive and repeatable manner in all normal *and* upset conditions. The systems will be challenged to perform to design standards over its full operating range.

The CA will execute the Functional Performance Tests for all systems. The Installing Contractors and/or Equipment Vendors will be responsible for creating the test conditions outlined in the FTP protocol as well as for providing qualified technical labor and support to operate the equipment during FTP testing.

The following general descriptions for each system provide an overview of the general testing requirements and goals that will be defined in the specific FIV, OPT and FPT protocols.

##### **6.4.1 Central Cooling Plant Equipment and Systems** (Cooling Towers, Condenser Water Pumping Systems, Chilled Water Pumping Systems)

### **Purpose of Functional Performance Testing**

The purpose of these commissioning procedures is to demonstrate that the installed systems are complete and meet the requirements specified in the “Acceptance Criteria.” outlined in this document. This system shall include but not necessarily limited to the following: cooling towers, condenser water pumps, chilled water pumps associated piping systems and components.

### **Method of Execution**

The specific methodology and instrumentation for each test will be described in the appropriate test section of the commissioning report. Commissioning testing of this system will include the following:

- **Field Installation Verification (FIV):** Inspection of all installed components prior to initiation of equipment operations. Components will include, but not necessarily be limited to, chilled water pumps, condenser water pumps, cooling towers and associated piping, valves, fittings and accessories.
- **Operational Performance Testing (OPT):** Execution and documentation of start up testing and adjustments, including but not necessarily limited to, alignments, rotation verification and electrical verification. OPT’s shall include analysis and test verification of equipment performance data provided by TAB contractor demonstrating that, under normal operating conditions, the equipment meets the minimum performance requirements of the contract documents and will be able to deliver design capacities required by the contract. The CxA will perform confirming tests of the TAB contractors work to demonstrate accuracy of the reported TAB results and repeatability of operational performance.
- **Functional Performance Testing (FPT):** Upon completion of the FIV’s and OPT’s, the CxA, in cooperation with the Installing Contractors shall utilize both the Building Management System and independent testing equipment provided by the CxA (as deemed appropriate by the CxA) to conduct integrated system performance testing. The system shall be operated in both steady state conditions and in upset conditions to demonstrate the systems response to normal and, in the opinion of the CxA and EPA-AWBERC, reasonably anticipated upset conditions.

### **Responsibilities**

**CxA:** Provide FIV, OPT and FPT check sheets and protocols to the General Contractor and Installing Contractors prior to execution of these protocols. Execute FIV’s upon certification of the General Contractor and Installing Contractors that systems are complete and ready for inspection. Witness the execution of all OPT’s. Supervise the execution of all FPT’s and provide data analysis and recommendations.

**General Contractor:** Provide coordination, support and personnel to support the execution of the tests described above.

**Installing Contractors (Sub):** Provide coordination, support and personnel to support the execution of the tests described above. Installing Contractors shall be responsible for operation of the systems and delivery of system accumulated data in a hard copy and electronic format in accordance with the specific requirements of each OPT and FPT provided during the construction phase by the CxA.

*Vendors:* Provide factory authorized personnel to execute OPT's as required by the contract or deemed appropriate by the Installing Contractors.

#### **Acceptance Criteria**

Acceptance of this system will be based upon the following criteria:

- Equipment Performance - The equipment provided under this contract shall be capable of operating at design capacity -0% to +10%.
- Piping Integrity- Piping leak tests shall meet the requirements of the project specifications.

#### **Summary of Documentation**

Completion of this commissioning Procedure is demonstrated by the following documentation:

- Executed Commissioning Procedures (FIV's, OPT's, FPT's)
- Testing, Adjusting and Balancing Report
- Contractor or Factory Start-up Documentation.
- Piping Systems Hydrostatic Test Report
- Operations and Maintenance Submittals
  - Equipment Data Sheets
  - Installation Data Sheets
  - Operating Data Sheets
  - Spare Parts List
- Operating Procedures
- Training Documentation

### **6.4.2 Temperature Control/Facility Management System**

#### **Purpose of Functional Performance Testing**

The purpose of these commissioning procedures is to demonstrate that the temperature control and facility management systems and components provided in support of the equipment installation are capable of controlling and maintaining conditions in accordance with the "Acceptance Criteria" outlined in this document.

The intent of the tests outlined in this plan is to demonstrate the ability of the control system both to achieve the Acceptance Criteria and maintain the conditions in a stable, reliable and repeatable manner.

#### **Method of Execution**

The specific Methodology and instrumentation for each test are described in the appropriate test section of the commissioning report. Commissioning testing of this system will include the following:

- Control System Point to Point Test - Verification of control wiring, tubing, and point configuration to controlled component to demonstrate complete and proper installation.

- Control Loop Tuning and Setpoint Test - Control system operation will be tested to demonstrate stable and repeatable operation of system and reasonable response times to system upset.
- Monitoring & Alarming Function Testing - Operation of all monitoring & alarming functions in the system shall be tested to demonstrate proper operation, messaging, indication and archiving.
- Control Component Calibration Test - Verification of calibration of control system components will be performed to demonstrate proper and accurate device monitoring and control.
- Control System Software Testing - Verification of control system software will be performed to demonstrate proper sequence of operation, lack of dead code in program, and functionality of program.
- Functional Performance Testing (FPT's) – Verification that all integrated system operate in a stable fashion under both steady state and upset conditions. Systems shall operate in a stable fashion under normal steady state conditions created during testing. System failures shall be simulated and the systems shall respond in a manner that both protects system components and provides a failure response that maintains building operations in accordance with the design intent.

### **Responsibilities**

*CxA:* Provide FIV, OPT and FPT check sheets and protocols to the General Contractor and Installing Contractors prior to execution of these protocols. Execute FIV's upon certification of the General Contractor and Installing Contractors that systems are complete and ready for inspection. Witness the execution of all OPT's. Supervise the execution of all FPT's and provide data analysis and recommendations.

*General Contractor:* Provide coordination, support and personnel to support the execution of the tests described above.

*Installing Contractors (Sub):* Provide coordination, support and personnel to support the execution of the tests described above. Installing Contractors shall be responsible for operation of the systems and delivery of system accumulated data in a hard copy and electronic format in accordance with the specific requirements of each OPT and FPT provided during the construction phase by the CxA.

*Vendors:* Provide factory authorized personnel to execute OPT's as required by the contract or deemed appropriate by the Installing Contractors.

The Installing Contractor shall complete the installation of the controls system components prior to execution of the project FIV's (inspections, point-to-point testing) for these components. Upon completion of FIV's, the Installing Contractor shall complete startup, and calibration of the control system components and sub-systems prior to the start of OPT's (Control Loop Tuning and Setpoint Test, Monitoring & Alarming Function Testing, Control Component Calibration Test and Control System Software Testing) for this system. System Commissioning Agent, in cooperation with the Contractor and his temperature control system sub contractor, will perform commissioning testing listed above to verify start up and operation of the completed Temperature Control/Energy Management System.

## **Acceptance Criteria**

Acceptance of this system will be based upon the following criteria:

- **Point to Point Verification** - The test shall demonstrate that each control point is properly configured for the intended purpose and that each control point is connected to the proper control device through continuous tubing and/or wiring. The test shall demonstrate that the each OWS graphical element is correctly assigned to the proper device.
- **Tuning and Setpoint Verification** - The test shall demonstrate that each control loop has the ability to control in a stable and repeatable manner as specified in the commissioning procedure. All control setpoints are documented. Control loop stability shall be determined to be a stable output (normally  $\pm 20\%$  of output) in normal steady state operations and a quarter decay response to set point changes.
- **Monitor & Alarm Function Testing** - The test shall demonstrate that each system monitoring and alarming point and specified alarm response is operating properly and provides the appropriate alarm messaging, archiving and indication.
- **Component Calibration Verification** - Calibration shall be field verified for 100% of all calibrated devices. Calibration shall be within specified ranges for each control device verified. Except for humidity sensor, all devices shall be calibrated in the field. Humidity sensors shall be provided with factory calibration certificates and performance shall be verified at a single operating point in the field.
- **Control System Software Testing** - Line by line walk through of software shall demonstrate that the Control System Software is complete, contains no dead code, and maintains all functions necessary to maintain the desired sequence of operation for each system.
- **Functional Performance Testing** - The test shall demonstrate that each control loop in an integrated operation has the ability to control in a stable and repeatable manner as specified in the commissioning procedure. Control loop stability shall be determined to be a stable output (normally  $\pm 20\%$  of output) in normal steady state operations and a quarter decay response to set point changes. Restoration of service after correction of upset failures shall occur within 5 minutes of resumption of normal operations.

## **Summary of Documentation**

Completion of this commissioning Procedure is demonstrated by the following documentation:

- Executed Commissioning Procedures (FIV's, OPT's, FPT's)
- Instrument Calibration Records
- Test Equipment Calibration Records
- Control System Software Code
- As-Built Control Drawings
  - Sequences of Operation
  - System Points List
  - Panel Layouts

- Operations and Maintenance Submittals
  - Equipment Data Sheets
  - Installation Data Sheets
  - Operating Data Sheets
  - Spare Parts List
- Operating Procedures
- Training Documentation

### 6.4.3 **Electrical Distribution Systems**

#### Purpose of Commissioning

The purpose of these commissioning tests is to demonstrate that the electrical system is capable of providing a reliable power source to the systems and components under the electrical operating conditions outlined in the Contract Documents.

#### Method of Execution

The specific Methodology and instrumentation for each test are described in the appropriate test section of the commissioning report. Commissioning testing of this system will include the following:

- Ground Continuity Testing – Ground continuity shall be verified for panels, receptacles, switches, outlets, and other electrically operated devices.
- Underground Cable Verification – Testing shall be conducted according to IPCEA specifications and Specification section 16121.
- Ground-Fault Circuit-Interrupters – Verification of electrical shock protection.

#### **Responsibilities**

*CxA:* Provide FIV and OPT check sheets and protocols to the General Contractor and Installing Contractors prior to execution of these protocols. Execute FIV's upon certification of the General Contractor and Installing Contractors that systems are complete and ready for inspection. Witness the execution of all OPT's.

*General Contractor:* Provide coordination, support and personnel to support the execution of the tests described above.

*Installing Contractors (Sub):* Provide coordination, support and personnel to support the execution of the tests described above. Installing Contractors shall be responsible for operation of the systems and delivery of system accumulated data in a hard copy and electronic format in accordance with the specific requirements of each OPT and FPT provided during the construction phase by the CxA.

*Vendors:* Provide factory authorized personnel to execute OPT's as required by the contract or deemed appropriate by the Installing Contractors.

#### Acceptance Criteria

- Ground Continuity Testing – Continuity shall exist for all ground circuits.
- Underground Cable Verification – Acceptance will be in accordance with IPCEA specifications.

- Ground-Fault Circuit-Interrupters – An Imbalance of current between the hot and neutral legs will cause the GFCI internal contacts to open.

#### Summary of Documentation

Completion of this commissioning Procedure is demonstrated by the following documentation:

- Executed Commissioning Procedures (FIV's, OPT's)
- Contractor Field Quality Control Check Sheet
  - Switch Operation (Circuit Breakers)
  - Heater Ratings
  - Fuse Ratings
  - Electrical Connection Tightening Torque
  - Insulation Level Resistance Tests
  - Electrical Continuity Checks
  - Ground Resistance Tests
  - GFI Circuitry Test
- As-Built Electrical Drawings

### **7.0 OPERATION AND MAINTENANCE MANUALS**

The System Commissioning Agent will be responsible for the review of assembled Operations and Maintenance Manuals and all related documentation and recommendation to EPA-HQ, EPA-AWBERC and Cannon regarding acceptance of the O&M Manuals. The O & M Manuals will include the following for each system:

- System Description
- Operating Conditions
- Setpoint Parameters
- Equipment and Systems Installation Data Sheets
- Operation and Maintenance Data Sheets
- Standard Operating Procedures
- Preventive Maintenance Procedures

The Contractor and all subcontractors, will be responsible for providing all equipment and systems installation, operation, and maintenance data sheets, and warranty information required by the contract documents in the O & M manuals in the final assembled manuals.

### **8.0 TRAINING**

The Commissioning agent will review, pre-approve and coordinate the training provided by the Contractor. The Contractor will submit a written training agenda to the Commissioning Agent for approval for all training. The Commissioning Agent will provide the commissioning team with the information required to coordinate and schedule the training session to be provided by the Contractors and Vendors on the project. The Commissioning Agent will also be responsible for documenting the training sessions. Each Contractor will be responsible to provide the training services specified in the project documentation.

Training Agendas shall include a combination of ‘classroom training’ and equipment training. Training sessions shall include, as a minimum, the following elements:

*Overview of the equipment, components and/or systems provided.* Overview shall include a description of components, assembly and intended normal operation of these devices

*Description of ‘Normal Operating Procedures,’* including but not necessarily limited to normal and emergency start/stop and alarm recognition and response.

Description of Maintenance Requirements necessary to maintain the equipment in top operating condition and to protect the warranty.

*Description of Typical Issues* that an operator may encounter in the normal and upset operation of the installed systems and equipment. This portion of the training should focus on the operational experience of the trainer in the use and maintenance of the equipment.

*Description of the Information in the O&M Manual.* Review the arrangement of the O&M Manual and demonstrate its functionality to the operators.

### **Responsibilities**

*CxA:* Coordinate training schedule, review and approve training agendas, document completed training for the commissioning record.

*EPA-AWBERC:* Schedule and coordinate the attendance of all appropriate personnel at each scheduled training session. Actively participate with the project contractors in the training process.

*General Contractor:* Provide coordination, support and personnel to support the training requirements of the project specifications. Submit Training Agendas for approval no less than 4 weeks prior to initiation of training activities.

*Installing Contractors (Sub):* Provide coordination, support and personnel to support the training requirements of the project specifications. Submit Training Agendas to the General contractor for approval no less than 6 weeks prior to initiation of training activities.

*Vendors:* Provide factory authorized personnel to support Installing Contractors in the execution of the training requirements of the Project Specifications.

### ***APPENDIX A: Sample Commissioning Documents***

- A. Commissioning Process Matrix
- B. Commissioning Duration Schedule (Sample)
- C. Commissioning Document List (Sample)
- D. Commissioning Documents (Samples)

<b>Commissioning Process Matrix</b>				
<b>Task</b>		<b>Description</b>	<b>Documents</b>	<b>Comments</b>
<b>Construction Phase Commissioning</b>				
1.	Commissioning Scoping Meeting	<ul style="list-style-type: none"> <li>Conduct an initial commissioning meeting with all contractors and commissioning team members. The purpose of the meeting will be to establish the purpose and proposed process for commissioning this facility in the construction, acceptance and warranties phases of the project. Review the individual roles and responsibilities of each participating commissioning team member as specified in the Construction Documents.</li> </ul>	<ul style="list-style-type: none"> <li>Meeting Minutes</li> <li>Final Commissioning Plan with specific with specific individual responsibilities identified.</li> </ul>	
2.	Prepare Duration Schedule for Commissioning Activities	<ul style="list-style-type: none"> <li>Based on the final commissioning plan, Prepare a duration schedule for the contractors for the commissioning activities required by the commissioning plan. This duration schedule should be incorporated into the contractor's project schedule to track all commissioning activities of the commissioning team.</li> </ul>	<ul style="list-style-type: none"> <li>Duration Schedule</li> </ul>	<ul style="list-style-type: none"> <li>Facilitate Schedule Coordination and Approve Construction Schedule</li> </ul>
3.	Submittal & Shop Drawing Review	<ul style="list-style-type: none"> <li>Review all pertinent approved shop drawings to support the Commissioning Process. Review of the shop drawings is for the purpose of developing appropriate FIV, OPT and FPT documents. Submittals &amp; Shop drawings shall be reviewed for commissionability, maintainability and for compliance to the OPR.</li> <li>Note any issues identified in the Shop Drawing Review that might compromise the final commissioned system on the 'Commissioning Review Log' and submit comment to the Design Team for resolution.</li> </ul>	<ul style="list-style-type: none"> <li>Commissioning Review Log</li> </ul>	<ul style="list-style-type: none"> <li>Cx reviews submittals &amp; shop drawings that have already been reviewed/approved by the design team.</li> </ul>

<b>Commissioning Process Matrix</b>				
<b>Task</b>		<b>Description</b>	<b>Documents</b>	<b>Comments</b>
4.	Finalize Construction Commissioning Plan	<ul style="list-style-type: none"> <li>Based on the work completed in the items above, we will finalize the Commissioning Plan for this project. The final commissioning plan will incorporate all changes established by review with your staff and the design team members. The final commissioning plan will also include complete FIV, OPT and FPT protocols for each system.</li> </ul>	<ul style="list-style-type: none"> <li>Final Construction Commissioning Plan</li> <li>Create all FIV, OPT and FPT documents. Design FPT protocols.</li> </ul>	
5.	Field Inspection Verifications (FIV)	<ul style="list-style-type: none"> <li>During the course of construction, visit the site to inspect the progress of construction with respect to the systems being commissioned. The purpose of the inspections is to verify that the construction complies with the plans &amp; specifications and standard construction quality practices.</li> </ul>	<ul style="list-style-type: none"> <li>FIV Check Sheets</li> <li>Daily Log</li> <li>Commissioning Issues Log</li> </ul>	
6.	Commissioning Team Meetings	<ul style="list-style-type: none"> <li>Hold commissioning meetings on a regular basis with the commissioning team to review progress of the commissioning effort and reinforce individual responsibilities. Review completed work and agree upon the acceptability of the delivered product.</li> </ul>	<ul style="list-style-type: none"> <li>Meeting Minutes</li> <li>Commissioning Issues Log</li> </ul>	
7.	Complete all FIV's	<ul style="list-style-type: none"> <li>Complete all field inspection verifications. A completed FIV indicates the system or piece of equipment is ready to be started and OPT's performed.</li> </ul>	<ul style="list-style-type: none"> <li>Completed FIV check sheets.</li> <li>Commissioning Issues Log</li> </ul>	
8.	Operational Performance Tests (OPT)	<ul style="list-style-type: none"> <li>Observe or facilitate all equipment and system start up procedures. The Contractor will execute all start up and point-to-point tests and the Cx will witness execution of all OPT's. .</li> </ul>	<ul style="list-style-type: none"> <li>Completed OPT's.</li> <li>Commissioning Issues Log</li> </ul>	

<b>Commissioning Process Matrix</b>				
<b>Task</b>		<b>Description</b>	<b>Documents</b>	<b>Comments</b>
<b>Acceptance Phase Commissioning</b>				
9.	Functional Performance Tests (FPT)	<ul style="list-style-type: none"> <li>Observe and facilitate all FPT testing. FPT's shall be designed by the Cx and performed by the contractors.</li> </ul>	<ul style="list-style-type: none"> <li>FPT Check Sheets</li> <li>Commissioning Issues Log</li> </ul>	
10.	Operator Training	<ul style="list-style-type: none"> <li>Work with the contractor and owner to schedule and plan training activities so that training occurs in a coordinated and coherent fashion. Assist in the development of training schedules and agendas, encourage the use of a combination of "classroom" and field training, and assist the contractors in the development of training agendas for each system or component installed in the project.</li> <li>Contractors and vendors provide all training. Additional skill training can be provided as an additional scope item if desired by the owner.</li> </ul>	<ul style="list-style-type: none"> <li>Coordinated Training Agendas</li> </ul>	
11.	Prepare Final Commissioning Report	<ul style="list-style-type: none"> <li>Based on the accumulated commissioning work completed as described above, we will assemble the data into a final commissioning report. The final report will incorporate the final record documents for each system, as appropriate. The report will also include a summary of commissioning that will highlight the final condition of each system commissioned.</li> </ul>	<ul style="list-style-type: none"> <li>Final Commissioning Report</li> </ul>	<ul style="list-style-type: none"> <li>If Warranty Phase commissioning or deferred testing (off season) is included in the scope of work, this report can be submitted as a draft report pending completion of final testing and inspections.</li> </ul>

***Commissioning Duration Schedule***  
***Sample For Illustrative Purposes Only***

<b><i>Commissioning Activity</i></b>		<b><i>Activity Description</i></b>	<b><i>Duration</i></b>	<b><i>Precedent Conditions</i></b>
<b><i>Central Plant Equipment</i></b>				
	Boiler Operational Performance Test (OPT)	Start-up performed by the boiler manufacturer.	2 weeks	Boiler Field Installation Verification (FIV)
	Boiler Building Automation System FIV	Verification of installation of the boiler control system.	2 days	Complete installation of the boiler BAS system , including control panels, devices, and all associated wiring.
	Boiler Building Automation System OPT	Instrumentation and controls operational performance test.	1 day	Boiler Building Automation System FIV
	Chiller Operational Performance Test (OPT)	Start-up performed by the chiller manufacturer.	1 week	Chiller Field Installation Verification (FIV)
	Chiller Building Automation System FIV	Verification of installation of the chiller control system.	1 day	
	Chiller Building Automation System OPT	Instrumentation and controls operational performance test.	2 days	Chiller Building Automation System FIV
	Cooling Tower Operational Performance Test (OPT)	Start-up testing performed by contractor and witnessed by CA.	2 days	Cooling Tower Field Installation Verification (FIV)
	Cooling Tower Variable Frequency Drive FIV	Verification of installation of VFD and associated wiring and programming.	1 day	Complete installation of each variable frequency drive
	Cooling Tower Variable Frequency Drive OPT	Start-up testing performed by contractor and witnessed by CA.	1 day	Cooling Tower Variable Frequency Drive FIV
	Cooling Tower Building Automation System FIV	Verification of installation of the controls cabinet, controllers, controlled devices, sensors, and associated wiring.	1 day	Complete installation of building automation system
	Cooling Tower Building Automation System OPT	Start-up and check-out performed by the controls contractor.	1 day	Cooling Tower Building Automation System FIV
<b><i>Chilled Water Distribution System</i></b>				

***Commissioning Duration Schedule***  
***Sample For Illustrative Purposes Only***

<b><i>Commissioning Activity</i></b>		<b><i>Activity Description</i></b>	<b><i>Duration</i></b>	<b><i>Precedent Conditions</i></b>
	Condenser Water Pump 1-3 FIV	Installation verification of each condenser water pump and its distribution system	1 day	Complete installation of the Condenser Water Pumps, including the distribution piping, wiring, and controls
	Condenser Water Pump 1-3 OPT	Start-up and check-out performed by the contractor.	1 day	Condenser Water Pump FIV
	Condenser Water Pump Building Automation System OPT	Instrumentation and controls operational performance test.	2 days	Condenser Water Pump 1-3 FIV
	Primary Chilled Water Pump 1-3 FIV	Installation verification of each Primary Chilled water pump and its distribution system.	1 days	Complete installation of the Primary Chilled Water Pumps, including the distribution piping, wiring, and controls.
	Primary Chilled Water Pump 1-3 OPT	Start-up and check-out performed by the contractor.	3 days	Primary Chilled Water Pump FIV
	Primary Chilled Water Pump Building Automation System OPT	Instrumentation and controls operational performance test.	2 days	Primary Chilled Water Pump 1-3 FIV;
	Secondary Chilled Water Pump 1-2 FIV	Installation verification of each Secondary Chilled water pump and the distribution system.	2 days	Complete installation of the Secondary Chilled Water Pumps, including the distribution piping, wiring, and controls.
	Secondary Chilled Water Pump 1-2 OPT	Start-up and check-out performed by the contractor.	3 days	Secondary Chilled Water Pump FIV
	Secondary Chilled Water Pump Building Automation System OPT	Instrumentation and controls operational performance test.	1 week	Secondary Chilled Water Pump 1-2 FIV; Secondary Chilled Water Pump 1-2 OPT
<b><i>Functional Performance Testing</i></b>				
	Hydronic System	Functional Performance Test of Hydronic Distribution System and associated wiring and controls.	6 days	All precedent FIV's and OPT's for Hydronic System.

## Commissioning Document List

Sample List for Illustration Purposes Only

Responsibility	Document Type	Specification Section	Document Description	Document ID
Commissioning Administrator	Design Phase Plan Review Report		A thorough review of the plan documents to establish the systems to be installed, the apparent design intent for each installed system	Design Phase Plan Review
Commissioning Administrator	Design Intent Summary Draft		A thorough review of the plan documents to establish the systems to be installed, the apparent design intent for each installed system. Prepare a draft Design Intent Summary to be finalized after the start of the Construction Phase of the project. This summary will be subject to review and approval by the Design	Draft Design Intent Summary
Commissioning Administrator	Design Intent Summary		a short summary of our understanding of the designer's intent for these systems. The design intent document will be focused on establishing the critical performance criteria for each system. Based on our agreement with the design team on the design intent document, we will establish Acceptance Criteria for each commissioning test protocol necessary to establish the acceptability of each installed system.	Design Intent Summary
Commissioning Administrator	Preliminary Cx Plan		Develop a preliminary commissioning plan for review and approval by Design & Construction. This draft of the commissioning plan will be used to set priorities and confirm the direction and ultimate target for our work.	Preliminary Cx Plan
Commissioning Administrator	Pre-bid Response and Recommendations		We will provide assistance in answering written questions (in the form of clarifications or addendum recommendations) during the bidding process.	Pre-bid Response and Recommendations
Commissioning Administrator	Construction Phase Plan Review		As part of the plan review, we will visit and inspect the site and review all pertinent shop drawings to support the plan review described above. Shop drawing review will be limited to commissioning review of approved shop drawings only.	Construction Phase Plan Review
Commissioning Administrator	Final Cx Plan		The final commissioning plan will incorporate all changes established by review with your staff and the design team members. The final commissioning plan will also include complete start up checksheets and testing protocols for each system.	Final CSX Plan
Commissioning Administrator	Cx Duration Schedule		Based on the final commissioning plan, we will prepare a duration schedule for the contractors for commissioning activities required by the commissioning plan.	Cx Duration Schedule
Equipment Manufacturer	Contractor Startup	15561, 3.3	Kitchen hood make up air unit operational performance test which includes the fan, heating section and associated ductwork by factory authorized service representative.	HRU1.OPT
Commissioning Administrator	Field Installation Verification	15815	AHU-1 air distribution system field installation verification which includes ducts, duct accessories, fire dampers, smoke damper, insulation and diffusers.	ADS AHU1.FIV
Commissioning Administrator	Field Installation Verification	15815	AHU-2 air distribution system field installation verification which includes ducts, duct accessories, fire dampers, smoke damper, insulation and diffusers.	ADS AHU2.FIV
Commissioning Administrator	Field Installation Verification	15815	AHU-3 air distribution system field installation verification which includes ducts, duct accessories, fire dampers, smoke damper, insulation and diffusers.	ADS AHU3.FIV
Commissioning Administrator	Field Installation	15815	AHU-4 air distribution system field installation verification which includes ducts, duct	ADS AHU4.FIV

<b>Responsibility</b>	<b>Document Type</b>	<b>Specification Section</b>	<b>Document Description</b>	<b>Document ID</b>
Administrator	Verification		accessories, fire dampers, smoke damper, insulation and diffusers.	
Commissioning	Field Installation	15815	AHU-5 air distribution system field installation verification which includes ducts, duct	ADS AHU5.FIV
Administrator	Verification		accessories, fire dampers, smoke damper, insulation and diffusers.	
Commissioning Administrator	Field Installation Verification	15815	AHU-6 air distribution system field installation verification which includes ducts, duct accessories, fire dampers, smoke damper, insulation and diffusers.	ADS AHU6.FIV
Commissioning Administrator	Field Installation Verification	15815	AHU-7 air distribution system field installation verification which includes ducts, duct accessories, fire dampers, smoke damper, insulation and diffusers.	ADS AHU7.FIV
Commissioning Administrator	Field Installation Verification	15815	AHU-8 air distribution system field installation verification which includes ducts, duct accessories, fire dampers, smoke damper, insulation and diffusers.	ADS AHU8.FIV
Equipment Manufacturer	Field Installation Verification	15725, 3.4	Modular Indoor Air Handling Unit 1 field installation verification which includes the supply fan, return fan, heat recovery wheel, cooling coil, heating coil pre-heat coil, control dampers and filters by factory authorized service representative..	AHU1.FIV
Equipment Manufacturer	Field Installation Verification	15725, 3.4	Modular Indoor Air Handling Unit 2 field installation verification which includes the supply fan, return fan, heat recovery wheel, cooling coil, heating coil pre-heat coil, control dampers and filters by factory authorized service representative..	AHU2.FIV
Equipment Manufacturer	Field Installation Verification	15725, 3.4	Modular Indoor Air Handling Unit 3 field installation verification which includes the supply fan, return fan, heat recovery wheel, cooling coil, heating coil pre-heat coil, control dampers and filters by factory authorized service representative..	AHU3.FIV
Equipment Manufacturer	Field Installation Verification	15725, 3.4	Modular Indoor Air Handling Unit 4 field installation verification which includes the supply fan, return fan, heat recovery wheel, cooling coil, heating coil pre-heat coil, control dampers and filters by factory authorized service representative..	AHU4.FIV
Equipment Manufacturer	Field Installation Verification	15725, 3.4	Modular Indoor Air Handling Unit 5 field installation verification which includes the supply fan, return fan, heat recovery wheel, cooling coil, heating coil pre-heat coil, control dampers and filters by factory authorized service representative..	AHU5.FIV
Equipment Manufacturer	Field Installation Verification	15725, 3.4	Modular Indoor Air Handling Unit 6 field installation verification which includes the supply fan, return fan, heat recovery wheel, cooling coil, heating coil pre-heat coil, control dampers and filters by factory authorized service representative..	AHU6.FIV